

TRANSPORTATION-RELATED ENVIRONMENTAL RESEARCH AND DEVELOPMENT ISSUES AND FUTURE PRIORITIES -DISCUSSION PAPER

by
MONENCO CONSULTANTS LIMITED
for
TRANSPORTATION DEVELOPMENT
CENTRE
POLICY COORDINATION GROUP
TRANSPORT CANADA

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August 1990



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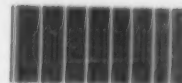
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The contents of this report reflect the views of Monenco Consultants Limited and are not necessarily the official view or opinions of the Transportation Development Centre of Transport Canada.

Ce document est également disponible en français: "Document de discussion des travaux actuels et des projets futurs de recherche et développement sur les questions du transport et de l'environnement", TP 10551F.



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16. Abstract This report reviews the current status to December 1989 of environmental research and development either in progress or under consideration by Transport Canada. The environmental R&D efforts are summarized and are based on input from interviews with representatives from Transport Canada's four modal groups (Aviation, Marine, Airports Authority and Surface). It is supplemented by a review of currently available literature, which was used to identify additional transportation-related environmental issues and research topics that could be of interest to Transport Canada. A detailed inventory of recently completed, proposed and active ER&D programs is provided. This report is intended as a discussion and planning document for Transport Canada to assist in the further planning and co-ordination of its environmental R&D program.					
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16. Résumé Dans ce document, on passe en revue les travaux actuels de R&D environnementaux et les nouveaux projets envisagés par Transports Canada (décembre 1989). Grâce à une série d'entretiens avec des représentants de quatre divisions de Transports Canada (transports aérien, maritime, routier/ferroviaire et le Groupe de gestion des aéroports), on a fait l'inventaire des travaux de R&D ayant trait au transport et à l'environnement. En outre, afin de souligner d'autres problèmes environnementaux, on a fait un dépouillement minutieux de toute la documentation actuelle où il est question d'études et de travaux de R&D sur les questions concernant le transport et l'environnement et qui seraient susceptibles d'intéresser le ministère des Transports. On a fait un tour d'horizon détaillé de tous les programmes de R&D environnementaux, qu'ils soient complétés, en cours ou proposés. Ce document a pour but de fournir les éléments clé de discussion et de planification nécessaires pour entreprendre et coordonner l'avancement de programmes de R&D environnementaux.				
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PREFACE

This discussion paper was prepared to catalogue current and proposed research and development programs sponsored by the Transportation Development Centre, Policy and Coordination Group, of Transport Canada. It is intended to provide the reader with an overview of the programs and to comment on their applicability to the transport modes, from an environmental point of view.



SUMMARY

The Transportation Development Centre of Transport Canada contracted Monenco Consultants Limited to evaluate the current level of activity, future requirements and available resources for environmental research and development in order to compile an inventory and to determine Transport Canada's present capabilities and resources to undertake new projects.

Interviews were conducted with representatives of the Transport Canada's four modal groups (Aviation, Marine, Airports and Surface) in Ottawa in November 1989. This was followed by a review of current literature which included Monenco's experience in transportation-related environmental issues.

Transport Canada and Monenco decided that the research and development programs would focus on seven key environmental topics:

- o engine emissions/fuel efficiency;
- o long-term climatic change;
- o noise;
- o spills and leaks;
- o waste management;
- o transportation of dangerous goods; and
- o infrastructure issues.

Tables i to v summarize the current thrust of environmental R&D by the four modal groups and the Policy and Coordination Group with respect to the seven topics listed above. The tables summarize information received by Monenco from Transport Canada during the November 1989 interview sessions.

Current Transport Canada R&D programs place emphasis on studies of engine emissions, marine spills and transportation of dangerous goods. Although assignment of priority to these endeavours is well-placed, it has been noted by the various modal groups that resources are not adequate. Since transportation activities have contributed much to the current high profile of the previously mentioned topics of study, continued R&D is well-advised. This does not necessarily imply that R&D is not required in other areas such as noise, long-term climatic change, waste management and infrastructure issues. Indeed there are unique problems presented by noise and waste management at airports which merit high priority. However, many of these issues are currently the subject of numerous R&D programs by various agencies in both the public and private sectors. Research priorities should therefore take other R&D programs into consideration.

It is noted that the inter-disciplinary nature of several of the environmental concerns resulted in research which could produce spin-off benefits in other related concerns. For example, studies to reduce engine



emissions may help to provide solutions to problems of long-term climatic change. Noise reduction in jet turbine engines was a spin-off benefit of design improvements for fuel efficiency. Virtually all environmental concerns can affect infrastructure siting and decommissioning. Thus, in developing R&D programs, results from past internal and external programs should be carefully reviewed to avoid duplication of effort.

Recommendations for future environmental R&D are given in Section 6 of this report. Highlights of these recommendations are that:

- o the majority of engine emission studies remain the responsibility of the Surface Group, with emphasis on automotive engine studies which can be adapted to marine and rail applications. Aircraft engine emission studies conducted within the Aviation Group for the purpose of assessing emissions caused by air-side operations should continue;
- o long-term climatic change R&D continue to place priority in the development of a management plan for the phase out of chlorofluorocarbons (CFCs) and replacement of existing halon fire control systems with less environmentally harmful systems;
- o noise control studies continue to be conducted by the Airports and Aviation groups;
- o spill prevention technologies and methods (i.e.: tanker safety) for land and marine transport be examined in addition to means to expedite spill response (i.e.: through contingency planning, development of national inventories of emergency equipment, and development of expert systems);
- o Transport Canada introduce several waste management initiatives including: encouraging private industry to reduce packaging; disposing of airport wastes and recycling of glycol; reviewing management programs for ship waste disposal; and, in general, applying 4R waste management concepts (reduction, reuse, recovery, and recycling) to transport;
- o the Transportation of Dangerous Goods (TDG) Directorate, in cooperation with Environment Canada and industry, embark on programs to develop expert systems to assist in the day-to-day application of TDG, and investigate the feasibility of developing a continuously updated tracking system, and to determine if amendments to regulations under TDG to accommodate the Canadian Environmental Protection Act (CEPA) are necessary; and
- o guidelines for decommissioning abandoned transport infrastructure be addressed as well as development of expert system software for determining environmental impact assessments (EIAs) so that costs and alternatives can be built into the process of sustainable development.



Implementation strategies for environmental R&D programs should seek to maximize effectiveness through multi-jurisdictional initiatives and cooperation. There is potential for cooperation with all levels of government in Canada and internationally. Industry, in particular the automotive, aerospace and petroleum industries, has shown support for environmental R&D in the past and should be regarded as a potential partner in joint programs.

Selection criteria for transportation related environmental R&D should focus on:

- o uniqueness to the Canadian transportation system or manufacturer capabilities (i.e., where it can be identified that no other jurisdiction has research in progress);
- o prioritization of short- and long-term issues including some qualitative risk assessment;
- o subjects which complement other research; and
- o programs which have international or other jurisdictional support for the work to be done in Canada.

The modal groups in Transport Canada are well-staffed managerially and have some capabilities in certain areas to perform environmental research. The modal group environmental managers are also supported by the newly appointed environmental coordinator in the Policy and Coordination Group, who will play a key role in disseminating information and fostering intermodal program cooperation. Transport Canada also has the R&D capabilities of the National Research Council (NRC) and Environment Canada (Waste Water Technology Centre) at its disposal.

Despite these resources, there is very little technical support for environmental managers within Transport Canada. For this reason, most of the environmental R&D should be contracted out to private environmental specialists.



TABLE 1
TRANSPORT CANADA - AVIATION MODE
STATUS OF ENVIRONMENTAL RESEARCH AND DEVELOPMENT

ENVIRONMENTAL ISSUE	CURRENT R&D PROGRAMS	FUTURE R&D REQUIREMENTS
1. Engine Emissions/Fuel Efficiency	- o Emissions control design, in process or add on; - o Improved energy efficiency through improved combustion design and aerodynamic drag reductions; and - o Optimization of aircraft take-off profile to maximize efficiency, minimize emissions and noise.	- o NO_x effects from stratospheric flights; - o Further improvements to fuel efficiency; and - o Use of alternative fuels (e.g., hydrogen).
2. Long-Term Climatic Change	- o Improvements to enhance fuel efficiency, thereby reducing emissions of "greenhouse gases"; and - o Inventory of CFCs and their use.	- o Use of alternative fuels to reduce generation of "greenhouse gases"; - o Effects of NO_x on the stratosphere; and - o Development of alternative environmentally friendly fire-extinguishing systems to replace existing halon systems.
3. Noise	o Modifications to engine design (usually to improve fuel efficiency but also reduce noise as a side-effect).	
4. Spills and Leaks	o None.	o None.
5. Waste Management	o None.	- o Programs/initiatives to reduce packaging; and - o Disposal of decommissioned aircraft.
6. Transportation of Dangerous Goods (TDG)	o None.	o None.
7. Infrastructure Issues	o None.	o None (any aviation infrastructure R&D will be managed by Airports Group).



TABLE 11

TRANSPORT CANADA - MARINE MODE
STATUS OF ENVIRONMENTAL RESEARCH AND DEVELOPMENT

ENVIRONMENTAL ISSUE	CURRENT R&D PROGRAMS	FUTURE R&D REQUIREMENTS
1. Engine Emissions/Fuel Efficiency	- o Propeller designs; - o Fuel quality/availability versus Emissions (proposed); - o Experiments in ship propulsion and resistance; and - o Upgrading of existing numerical models to include hydroelastic modelling, wave pattern and resistance modelling, and modelling of screw propellers.	o Not high priority (R&D for marine engines can be adapted from surface mode R&D).
2. Long-Term Climatic Change	o All programs listed above relating to engine emissions have direct influence on the "Greenhouse Effect".	- o Management plan for phase out of halon fire control systems in ships; and - o Development of fire control systems to replace halon systems in ships.
3. Noise	- o Propeller designs; - o Experiments in ship propulsion and resistance; and - o Upgrading of existing numerical models to include hydroelastic modelling, wave pattern and resistance modelling, and modelling of screw propellers.	o Continued research to reduce noise below the waterline; surface noise not an area of concern.
4. Spills and Leaks	- o Marine spill cleanup R&D; - o Marine spill tracking; - o Development of expert systems software; and - o Research initiatives under Arctic Waters Regulatory Studies Plan (AWRSP).	- o Marine spill prevention R&D; - o Cleanup technology for spills in Arctic waters; - o Review of vessel traffic services (VTS) capabilities to improve tanker safety; - o Improved surveillance techniques to improve reporting of operational discharges and small spills at sea; - o Reactivation and upgrading of the National Emergency Equipment Locator System (NEELS);



TABLE 11 (Cont'd)

TRANSPORT CANADA - MARINE MODE
STATUS OF ENVIRONMENTAL RESEARCH AND DEVELOPMENT

ENVIRONMENTAL ISSUE	CURRENT R&D PROGRAMS	FUTURE R&D REQUIREMENTS
5. Waste Management	o Generation and treatment of ships' garbage.	- o Beach cleanup techniques; - o Development of a uniform and comprehensive spill reporting form; and - o Development of management plans for underground storage tanks for marine facilities. - o Management of wastes from deck washings, and hold cleanings; - o Ship sewage treatment and disposal; - o Substitution of non-hazardous products in place of hazardous products; - o Reduction of waste packaging initiatives; - o Control of contamination of Canadian waters during ballast water exchange from foreign ships; - o Disposal of derelict ships; - o Disposal of asbestos; and - o Disposal of waste materials following spill cleanup operations.
6. Transportation of Dangerous Goods	o None identified.	o None identified.
7. Infrastructure Issues	o None.	- o Decommissioning guidelines for abandoned ports and terminals; - o Development of guidelines for environmental impact assessments (EIAs) for proposed shipping facilities; - o Use of G.I.S. systems for data analysis; - o Development of baseline criteria for leasing and permitting shore-based facilities.



TABLE III

TRANSPORT CANADA - AIRPORTS GROUP
STATUS OF ENVIRONMENTAL RESEARCH AND DEVELOPMENT

ENVIRONMENTAL ISSUE	CURRENT R&D PROGRAMS	FUTURE R&D REQUIREMENTS
1. Engine Emissions/Fuel Efficiency	- o Emissions from fuel handling operations; and - o Combustion emissions from fires.	o Control of emissions from airports.
2. Long-Term Climatic Change	o Inventory of CFCs and their use.	o Development of alternative environmentally friendly fire-extinguishing systems to replace halon systems currently in use.
3. Noise	- o Airport (Noise) Externalities; - o Correlation between noise model and perceived airport noise; and - o 3rd party noise influences.	- o Testing of noise reduction techniques (noise budget, use of longer runway to avoid reverse thrust, regulations, etc.); and - o Point-source simulation (model).
4. Spills and Leaks	o UST management program. NOTE: AG has developed a manual for airport emergencies which includes a section on spills.	- o Spill <u>prevention</u> techniques; and - o Spill management expert system for use with chemicals.
5. Waste Management	- o Runoff treatment and disposal studies at Halifax International Airport; and - o Use of CMA as a de-icing agent.	- o Disposal of airside wastes from international flights; - o Glycol recovery and recycling; - o 4R program implementation for maintenance operations; and - o Replacement of hazardous products with non-hazardous products.
6. Transportation of Dangerous Goods.	o None.	o Not applicable concern to airports.
7. Infrastructure Issues	o None.	- o Development of baseline environmental status parameters to avoid cleanup liability following transfer of airport leases to private interests; - o Environmental impact assessment (EIA) guideline development; - o Expert systems and G.I.S. for EIAs; and - o Decommissioning guidelines development.



TABLE IV
TRANSPORT CANADA - SURFACE MODES
STATUS OF ENVIRONMENTAL RESEARCH AND DEVELOPMENT

ENVIRONMENTAL ISSUE	CURRENT R&D PROGRAMS	FUTURE R&D REQUIREMENTS
1. Engine Emissions/Fuel Efficiency	- o Reduction of engine emissions; - o Emissions inventories (proposed); - o Toxicology studies (proposed); - o Studies on emissions from volatilization of motor fuels (proposed); - o Examination of environmental effects of fuel additives (proposed); - o Automatic controls for refuelling propane tanks (proposed); - o Diesel engine and health effects monitoring; - o Use of alternative fuels; - o Regenerative power train systems; - o Improved engine materials; - o Reduction of rail car rolling resistance; - o Technologies to increase train efficiency; - o Real-time vehicle locators; - o Low temperature engine performance; - o Drag reduction on surface vehicles; - o Improved wind tunnel testing methods; - o Effects of fuel grade on engine performance; - o Emission analyzing techniques; - o Quantification of diesel spray characteristics and combustion; and - o Study of engine idling procedures, needs and alternatives.	- o Implementation of proposed programs; - o Adaptation of road transport engine R&D to rail and marine transport; - o Enhancements of public transportation to encourage use; and - o Technology to reduce dependence on combustion engines (use of electricity as an energy source).



TABLE iv (Cont'd)

TRANSPORT CANADA - SURFACE MODES
STATUS OF ENVIRONMENTAL RESEARCH AND DEVELOPMENT

ENVIRONMENTAL ISSUE	CURRENT R&D PROGRAMS	FUTURE R&D REQUIREMENTS
2. Long-Term Climatic Change	o Inventory and use of CFCs. Note: all programs examining combustion emissions will have an effect on long-term climatic change.	- o Same requirements as specified for engine emissions/fuel efficiency; and - o Development of alternative environmentally friendly fire extinguishing systems to replace halon systems currently in use.
3. Noise	o Noise and vibration studies.	NOTE: Most surface mode noise will require control partially through proper infrastructure/siting. - o Physiology/psychology of noise response; and - o Model/monitoring/response correlation development.
4. Spills and Leaks	o None.	- o Spill prevention programs; - o Expert systems for land-based spills; and - o Evaluation of spill risks from surface transport and means to reduce exposure to the public from dangerous spills.
5. Waste Management	o None.	- o Substitution of non-hazardous products for hazardous products; - o Initiatives to reduce waste packaging; and - o 4R strategy implementation for surface fleet maintenance operations (used oil, antifreeze recycling, metal salvage, etc.).
6. Transportation of Dangerous Goods	- o Rail car testing; - o Pressure vessel testing; - o Train speed studies; - o Development of TDG expert systems (proposed); - o Field inspection techniques; and - o Risk Analysis for dangerous goods transport.	o Feasibility of developing a continuously updated national tracking (scheduling) system.
7. Infrastructure Issues	- o Road sealant studies; and - o Snow removal studies.	o Decommissioning cleanup guidelines for rail line removal, decommissioning of rail terminals and yards.



TABLE v

TRANSPORT CANADA - POLICY AND COORDINATION GROUP
STATUS OF ENVIRONMENTAL RESEARCH AND DEVELOPMENT

ENVIRONMENTAL ISSUE	CURRENT R&D PROGRAMS	FUTURE R&D REQUIREMENTS
1. Engine Emissions/Fuel Efficiency	o None.	o None.
2. Long-Term Climatic Change	o Transport implications of global climate change (greenhouse effect); and o Inventory and use of halons in Transport Canada.	o Management and phase-out strategies for halons.
3. Noise	o None.	o None.
4. Spills and Leaks	o None.	o None.
5. Waste Management	o None.	o None.
6. Transport of Dangerous Goods	o Development of PCB regulations under CEPA (in cooperation with Environment Canada); and o Infectious materials packaging research.	o Development of other regulations for products regulated under CEPA in cooperation with Environment Canada; and o Review of hazards of dangerous goods on the environment (efforts to be coordinated between TDG and Environment Canada).
7. Infrastructure Issues	o None.	o Development of environmental impact assessment (EIA) guidelines; and o Development of G.I.S. and expert systems for EIAs.



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1. INTRODUCTION

1.1 Purpose

This document is intended to provide an overview of the environmental research and development issues and activities currently undertaken and proposed by Transport Canada and does not represent a detailed planning or policy document.

1.2 Objectives

The objectives of this discussion document are to:

- o provide an inventory of on-going environmental R&D projects in Transport Canada based on inputs provided to Monenco through interviews with selected Transport Canada staff in November 1989;
- o identify major transportation-related environmental issues and research topics;
- o summarize results from interviews with Transport Canada personnel in order to incorporate their perspectives on environmental issues, current research, and future needs and opportunities; and
- o stimulate future discussion within Transport Canada on its programs and requirements with respect to environmental research and development which will allow it to effectively address short- and long-term environmental concerns.

1.3 Background

One key aspect to maintaining growth and competitiveness in a global economy lies in the capability to provide safe, efficient and low-cost transportation for goods and services. Coupled with this is an increasing public awareness and acceptance that environmentally sound economic development or sustainable development will become a priority.

Transportation in Canada is heavily dependent on petroleum fuels. Statistics Canada (Catalogue #57-003) indicate that transportation activities are responsible for 65.4 percent of the national petroleum consumption. Most of this usage is attributed to road transport which accounts for more than 60 percent of the petroleum used by all modes of transport. The impacts of this degree of fuel consumption on air quality and the global climate pose serious considerations. Environment Canada projections for 1990 (quoted by TRANSPORT 2000) estimate that 462 kilotonnes of volatile organic compounds and 337 kilotonnes of NO_x will be released to the atmosphere from the operation of automobiles and light-duty gasoline-powered vehicles alone.



Other adverse environmental impacts of transportation activities include noise, waste generation, water pollution, land or other natural resource consumption and miscellaneous other impacts due to accidents.

1.4 Limitations

This overview of current and proposed R&D programs was limited due to the time available to review existing literature in detail and interview staff from Transport Canada and Environment Canada.



2. TRANSPORTATION AND ENVIRONMENT

2.1 Importance of Various Transport Modes

Transportation is Canada's largest economic sector. At \$106 billion/yr (1986 figures), the transportation industry represents 21 percent of the Canadian Gross Domestic Product. Of that 21 percent, private automobiles account for 13.8 percent, public passenger transportation for 5.2 percent and goods transport for 2 percent, (NRC 1989). According to information presented at the ministerial session on Transport and the Environment, (ECMT, 1989) future social and economic conditions are unlikely to change radically and thus current transportation trends are likely to continue. While passenger transport (private and public) is expected to grow steadily, the growth rate of goods transport is anticipated to lessen due to the increased demand for transport of goods which weigh less and are packaged in smaller sizes. Overall, rail transport utilization will likely decline while the aviation and road sectors will likely grow.

If projections that transportation will continue to dominate the Canada's Domestic Product are accurate, conforming to the concept of sustainable development will require a rigorous R&D program to address environmental issues.

2.2 Environmental Concerns

Table 1 highlights the major environmental concerns related to the principal transport modes identified by those individuals interviewed by Monenco in November 1989. The key transportation-related environmental issues may be summarized as follows:

- o engine emissions (CO, NO_x, VOC, HC, particulates, lead, etc.) and their associated health and ecological impacts;
- o long-term climatic change and the issues of global warming and stratospheric ozone concentration changes;
- o noise and/or vibration disturbance due to road traffic, airports and railway corridors;
- o arctic pollution, ship-ice interface;
- o oil spills or accidental releases of other products and pollution from leaking underground storage tanks;
- o waste management issues of:
 - solid waste disposal including disposal of contaminated and non-recyclable or non-recoverable materials and infrastructures,
 - liquid waste disposal or treatment, including wastewater treatment;



TABLE 3

MAJOR ENVIRONMENTAL CONCERNS OF PRINCIPAL TRANSPORT MODES*

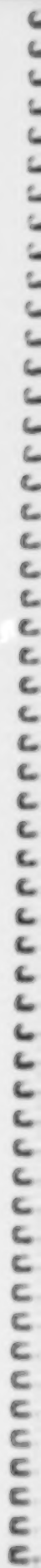
TRANSPORT MODE	AIR	WATER	SOLID WASTE	NOISE	LAND RESOURCE	OTHERS
AIR TRANSPORT	- Mainly NO_x Pollution - Stratospheric ozone	- Surface water drainage - Groundwater contamination due to spills - Glycol contamination - Underground storage tank problems	- General garbage - Disposal of old aircraft - Decommissioning of airport facilities	- Noise around airports	- Land for infrastructure	- Fuel dumping during emergency landings
MARINE/INLAND WATER TRANSPORT	- Diesel engine emissions	- Oil spills - Unauthorized discharges - Dredging - Hazardous waste discharge	- General garbage - Disposal of old vessels - Decommissioning of old port facilities	- Minimal	- Land for infrastructure	- Accidents involving fuels & hazardous substances
RAIL TRANSPORT	- Diesel engine emissions	- Spills - Herbicide application residues	- Abandoned lines, equipment and rolling stock - Obsolete facility decommissioning	- Noise in urban areas along rail lines	- Land for rights-of-way & terminals	- Derailment/collision involving hazardous substances
ROAD TRANSPORT	- Air pollution (CO, HC, NO_x, particulates & fuel additives (Lead)) - Global warming (CO_2, CFC) - Fuel handling	- Pollution due to surface runoff - Drainage modification - Discharge of hazardous substances	- Disposal of old vehicle - Used oil disposal - Asphalt disposal	- Major pollution along roads and in urban areas	- Land for infrastructure and resources for road building	- Accidents leading to release of hazardous substances

* From discussions with Transport Canada personnel (November, 1989).

- o risks incurred in the transportation of dangerous goods (TDG) through urban areas (representing an increasing cause of concern due to the potential for large-scale disaster); and
- o land used to support transport infrastructures and the associated adverse impact on property values, farmland and communities.

Many of these environmental concerns are inter-related (i.e., engine emission effects on long-term climatic change, spill management generating materials for waste management). As a result, environmental R&D in one particular problem area may yield spin-off benefits in another environmental concern.





3. CURRENT TRANSPORT CANADA ENVIRONMENT R&D THRUSTS AND FUTURE NEEDS

3.1 Engine Emissions

3.1.1 Background

The issue of engine emissions is broad and encompasses many aspects. For example, engine emissions generate significant environmental impacts due to:

- toxicity (carbon monoxide, organics, particulates, heavy metals);
- acid gases (CO_2 , CO, SO_2 , H_2S , NO_x); and
- photochemical activity (organics, NO_x , particulates).

Reducing engine emissions on a unit vehicle and/or fleet or mode basis has been reviewed by the scientific community at large in terms of:

- emissions control design (in-process or add-on);
- improved energy efficiency
 - combustion efficiency design,
 - aerodynamic drag reduction,
 - drive train efficiency;
- fuel substitution/composition modifications;
- fuel handling controls; and
- infrastructure management (the shift from private to public transportation, efficient traffic control to reduce engine idling for all modes, etc.).

Transport Canada's current and proposed environmental R&D programs by the various modal groups to control or reduce engine emissions are listed in the Appendix. It shows that the greatest R&D efforts are directed towards surface mode related activities, in particular the road transport mode.

The marine and rail mode contacts interviewed all believe that this is appropriate because:

- the engine markets and relative impacts from rail and marine are minor in comparison to road transport; and
- primary engine R&D in road transport can be readily applied to rail and marine, thus R&D in those areas would be duplication of effort.



3.1.2 Current Programs

Current R&D emphasis should be maintained. Opportunity exists for international cooperation (particularly with the U.S. Environmental Protection Agency).

From the Appendix it can be noted that activities to improve fuel efficiency or evaluate certain alternate fuels will also have a benefit in reducing CO₂ emissions which would offset (to a degree) global warming. Also, emission reductions from in-flight aircraft also hold the potential for reducing adverse effects on stratospheric ozone concentrations. Note that as noise is a manifestation of energy loss, improvements in energy efficiency often result in noise reductions (and vice versa).

3.2 Long-Term Climatic Change

3.2.1 Background

Gradual changes to the global climate appear to be occurring due to atmospheric contamination, some of which are directly attributable to transportation activities. Two mechanisms of this long-term climatic change have drawn world-wide concern and hence are candidates for present and continued R&D.

The first mechanism, commonly referred to as the "Greenhouse Effect", involves the global accumulation of fossil fuel exhaust gases (in particular, carbon dioxide) which, through its heat-insulating properties, could lead to significant and potentially catastrophic global warming within the next 50 to 100 years. As major sources of carbon dioxide emissions (through combustion of fossil fuels) all transportation modes will have a role to play in the reduction of greenhouse gas emissions.

The second mechanism of long-term climatic change urges an international phase-out of CFC use (Montreal Protocol (1988), an agreement drafted by 48 countries in an effort to halt deterioration of the ozone layer). It is widely accepted that chlorofluorocarbons (CFCs) have been adversely affecting the normal concentrations of ozone in the stratosphere. Since this ozone acts as an ultraviolet radiation filter in the atmosphere, reductions in stratospheric ozone could lead to a significant increase in ultraviolet radiation reaching the surface. This could have negative consequences for plant and animal life on the earth.

CFCs are utilized as the refrigerant for vehicle air conditioning systems, load refrigeration, and production of certain foamed plastic packaging/cushioning materials. In addition, the halons used in fire control systems (most notably aircraft) are CFCs. Engine emissions (e.g. NO_x) from stratospheric aircraft are thought to adversely affect "the ozone layer". The potential impacts of these emissions are thus, similarly, of major concern.

Due to the global nature of these issues, the solutions must also be global. International cooperation, agreement, and coordination are important co-requisites to action.



3.2.2 Current Programs

Interim short-term issues aimed at reducing greenhouse gas emissions would be:

- o improved energy efficiency
 - combustion efficiency
 - aerodynamic drag reduction
 - drive train efficiency;
- o shifts in utilization towards more energy efficient transport modes (shifts from the personal automobile towards mass transit, etc.); and
- o load/system management (making more efficient use of transport capabilities).

Longer-term issues aimed at eliminating greenhouse gas emissions from fossil fuel combustion would be:

- o shifts towards biomass fuels;
- o shifts towards non-carbon fuels; and
- o shifts towards electric ground transport.

Stratospheric ozone deterioration must be abated by the elimination of CFC use. Major producers of CFCs have developed chlorofluorocarbon substitutes (HFC 134a, Formacel S) for use in refrigeration and air conditioning systems and for blowing agents and aerosol propellants. Some of these substitutes are commercially available and many more are undergoing toxicity testing prior to market release. Substitutes for halon are currently being sought by the major halon producers.

Transport Canada has been an active player with respect to research of long-term climatic change. Through membership in the Organization for Economic Cooperation and Development (OECD) and cooperation with the federal Department of Environment, Transport Canada has lent support and provided data for several investigations into the Greenhouse effect and ozone depletion. Recent efforts included presentation of a paper on consequences of long-term climatic change (IBI 1988) at the 1st World Conference on the Changing Atmosphere (Toronto 1988) and cooperation with Environment Canada in preparation for the 2nd World Conference in Geneva in 1990.

Specific current research and development programs by Transport Canada are detailed in the Appendix.

Note that the aviation mode, with its direct interaction with the upper atmosphere, should be a more immediate priority area for research and development over other modes.



The road transportation mode leads most surface and marine transport research and development in the area of long-term climatic change. As such, gains derived from basic and applied road transport research will be of benefit in future application to the other modes.

Much of the engine emissions, fuel efficiency, and alternative fuels research being done will yield spin-off benefits in reducing greenhouse gas emissions.

The IBI study (The Implications of Long-Term Climatic Changes to Transportation in Canada, 1988) presented a number of future scenarios of what would happen to transport in Canada if global warming occurs. Transport Canada should give prevention of global warming priority over dealing with adapting/responding to global warming in setting its research and development priorities.

3.3 Noise

3.3.1 Background

Noise is often a side-effect of the operation of propulsion systems (engines, drive trains, surface interactions, etc.). It is, in effect, wasted energy.

Noise manifests itself as a most significant problem where people are in proximity to transportation systems. Airports and the noise generated during aircraft take-offs and landings have been significant sources of complaints from the public. Noise and vibration from rail traffic and larger road systems have also been complaint sources.

Noise complaints are a function of:

- o noise levels;
- o noise frequencies;
- o proximity to source; and
- o individual sensitivities and perceptions.

Control of noise impacts has been sought through means such as:

- o land use planning and regulation (zoning), especially for airports and railway corridors;
- o sound buffering, absorption, or dampening;
- o engine/mechanical design;
- o changes to aircraft approach and landing techniques (use of full length of runway to decrease use of "reverse thrust" braking);



- o system scheduling and/or route modification; and
- o vehicle/aircraft regulation/prohibitions and restrictions.

The assessment of noise levels near major transportation facilities (road or rail corridors, airports) is a key component of Transport Canada's environmental R&D program. Models to simulate and predict noise levels are indispensable tools for these assessments. The requirement for improved simulations demands continuing refinements and modifications to existing models.

3.3.2 Current Programs

Efforts to assess noise levels through models by Transport Canada are mainly at the proposal stage. Proposed simulation projects will consider noise at airports during regular airside operations, third-party noise influences, and models of aircraft engine run-up noise levels. The only simulation study of noise modelling active at the time of the writing of this document was being conducted by the NRC for marine operations. That study involves modifying existing numerical models to simulate hydroelastic effects, wave patterns, resistance and screw propellers for marine vessels.

Models for noise level simulation of major road traffic corridors were not identified by Transport Canada staff in the current and proposed R&D projects inventory. This may be due in part to the current availability of such models from Canadian and American sources. It is interesting to note that the STAMINA 2.0 computer model, the most common U.S. model in use for predicting noise from traffic travelling at constant speed, has recently been modified to simulate stop-and-go traffic noise levels that could be expected from controlled intersections and loop or slip ramps. This refined model may have relevant application to Canadian situations and therefore could form the basis for further R&D.

The Appendix shows that research and development on noise issues is active and required in all transportation modes. The most significant efforts have been directed at control of noise from the airports/aviation mode with equally important but lesser efforts directed towards other modes. We would suggest that the current balance of R&D effort be maintained.

3.4 Spills and Leaks

3.4.1 Background

Spills, for the purposes of this discussion refer to discrete incidents of accidental or unauthorized release of finite duration. Leakage is defined as unauthorized releases of indefinite duration.

Spills and leakage of contaminants to the environment represent major hazards to the quality of soil, air, surface water and groundwater.

Statistics maintained by Environment Canada from 1974 to 1983 indicate that 21,587 spills (representing 3,669,360 cumulative tonnes of material) were



reported to federal authorities (ENVIRONMENT CANADA 1987). The number of spills increased steadily from 1974 and peaked in 1980 at 2861 reported spills. The reported number of spills decreased to 1915 by 1983. Transportation-related activities were responsible for 16 percent of all spills.

The National Analysis of Trends in Emergencies (NATES) (as quoted by ECO/LOG Weekly, March, 1988) forecasts that:

- o the number of spills reported in the future will probably remain fairly constant or decline slightly;
- o transport activities will account for 10 to 20 percent of all spill events;
- o tank trucks and other motor vehicles will continue to be involved in 100 to 200 spills (mainly road accidents) per year; and
- o two-thirds of all spills will involve oil or petroleum products.

Leakage, on the other hand, is likely to originate from damaged underground storage tanks (USTs). Approximately 200,000 leaking USTs in Canada may be contaminating 260 million litres of groundwater every day (ECO/LOG WEEKLY, MAY 20, 1988). Several thousand of these USTs are located at Transport Canada facilities such as airports, railyards, and shipping terminals. In addition to the threat to groundwater quality and human health, migration of the subsurface contaminant plume can put public infrastructure and private property at risk of explosion hazards from ignitable fuel vapours.

R&D to deal with spills and leakage has logically focussed on preventive measures as well as containment and cleanup. An entire industry has been built to accommodate the needs for spill control products. R&D efforts of this industry have produced and continue to develop in the following areas:

- o sorbent materials, including hydrophobic/oeliophilic materials to remove hydrocarbons from water;
- o vacuumers which are safe for use in explosive environments;
- o skimmers for removal of floating hydrocarbons;
- o flammable vapour suppressants;
- o dispersants to facilitate cleanup of hydrocarbon emulsions;
- o neutralizing agents;
- o dredges for removal of sunken spills;
- o containment methodologies and remedial measures (including methods compatible with Arctic climates); and



- o computer-based expert systems to assist response teams in the management of spills in a thorough, orderly, and safe manner.

R&D specific to leaking USTs has produced:

- o continuous leak detection equipment;
- o cathodic protection to control metal deterioration;
- o standards for steel and fibre-reinforced plastic (FRP) tanks and piping;
- o tank and piping integrity tests; and
- o groundwater remediation techniques, including steam stripping, ultrafiltration, reverse osmosis, carbon adsorption, enhanced biodegradation, and ultra-violet treatment.

The level of effort currently expended in spill management R&D clearly reflects the serious nature of this issue. Technologic achievement in the development of remedial technologies, spill cleanup materials and equipment is apparent considering the wide selection of products available on the market. The large number of manufacturers competing in this area should ensure that R&D for improved products will continue. In the area of technology development for spill cleanup, a thorough review of current commercial technologies should be completed.

3.4.2 Current Programs

Transport Canada's current R&D programs on spill management focus on the development of strategies and deployment methods to manage marine spills, methods to track movement of spill plumes, and modification of technologies proven in temperate climate for use in Arctic spill situations. Emphasis has also been placed on the development of expert systems to ensure orderly, thorough and safe cleanup. In general, R&D efforts in marine spill management seem fairly well directed. It became apparent, however, after reviewing the scope of federal transport R&D that management of land-based spills such as those in railyards and on highways was unaddressed. Projections of 100 to 200 surface mode incidents involving spills suggest that this area should be reviewed for R&D priority.

Spills of aviation fuel are a frequent occurrence at airports, especially during fuelling operations and occasionally during startup and shutdown of turbine engines. Cleanup of airport spills, however, was previously addressed in the Airport Environmental Emergency Handbook (Transport Canada, 1983).

A federal public review panel on Canadian marine spill prevention and response capabilities identified spill prevention as having the highest priority for protection of marine and coastal environments (ECO/Log Weekly, Oct. 27, 1989). The limitations of existing spill response equipment was cited as the reason for assignment of this priority. The review panel also found that:



- o greater quantities of oil and chemicals are discharged to the environment from small, unreported marine spills than from large-scale spills;
- o tanker safety in Canadian waters is compromised by inadequacies in vessel traffic services; and
- o a national inventory of spill response equipment is not available.

Other subjects for R&D in spill management could include:

- o spill prevention strategies for land and marine modes and for Arctic climates;
- o tracking and cleanup methods for submerged chemical spills;
- o review of current vessel traffic services capabilities with studies to improve communication and procedures;
- o research into improved surveillance techniques to improve reporting of operational discharges and small spills and to discourage illegal discharges;
- o feasibility of reactivation and upgrading of the National Emergency Equipment Locator System (NEELS); and
- o development of effective methods for beach cleanups.

As a result of the Valdez oil spill off the Alaskan coast, the Canadian Petroleum Association (CPA), the Canadian Petroleum Products Institute (CPPI) and the Independent Petroleum Association of Canada (IPAC) all have set up programs and initiatives to study and establish oil spill contingencies. The CPPI has proposed cooperation with Transport Canada, stating that the Canadian Coast Guard should take the lead role in coordinating spill control efforts and industry should be responsible for handling practical spill operations (Oil & Gas Journal, December 1989). Transport Canada may wish to pursue further projects in cooperation with the petroleum industry for spill contingency planning and research and training programs.

The issue of leaking USTs has been addressed by Environment Canada, which led to the development of a Code of Practice for management of USTs. Environment Canada has also created a computerized inventory system ("Register of Underground Storage Tanks" or RUST) which has the capability to store information concerning construction details, age, contents, management practices, and some environmental sensitivity factors concerning USTs. The Airports Group has used RUST to establish a management plan for more than 1700 USTs at federal civil aviation facilities. Similar plans for other transport modes should also be addressed.

The development of expert systems for spill management was mentioned as a priority throughout literature and during interviews with Transport Canada and Environment Canada staff. It should be noted that working prototypes



for spill management exist, but are very limited in capability. The requirements for a spill expert system should include:

- o the ability to operate with a database of at least 3000 products;
- o the ability to provide substance classification;
- o the ability to incorporate models for calculating contaminant dispersion in soil, water and/or air; and
- o the ability to interface with existing commercially available databases containing information such as area maps (including sewer, underground utility and well locations) and precise details on chemical properties.

3.5 Waste Management

3.5.1 Background

Contemporary waste management has shifted emphasis from disposal of entire waste streams as a sole option to strategies of reduction, reuse, recovery, recycling and (4R strategy), prior to disposal of greatly reduced waste streams. Application of the 4R strategy (where possible) often pays dividends both economically as well as environmentally by reducing quantities of waste for disposal. It can also bring the additional benefits of reducing a feedstock or creating another saleable product. R&D to extend the 4R strategy to waste management has derived programs such as reduction of wastes through packaging of consumer goods (excluding dangerous goods), recycling of containers, reuse of washing fluids, and recovery of spent reusable sorbents by wringing or other extraction methods to name but a few.

Waste management and application of the 4R strategy could impact transportation in two ways. First, if transportation of waste is considered, the ramifications of reduction become clear i.e., less wastes to haul will reduce some of the transportation requirement. Reduction of packaging (which later becomes waste) will also reduce transportation requirements. Reduction of the volume of transport activity has environmental benefits to all of the key environmental issues.

The second impact of the 4R waste management concept on transport concerns wastes generated by transportation activities. Wastes from the transportation industry are generated by conveyance of passengers and livestock as well as through maintenance of modal fleets. Aside from reduction of consumer goods packaging used by passenger carriers, there is relatively little that can be done to reduce quantities of waste from passenger and livestock transport. Maintenance activities, however, provide numerous opportunities for exercising 4R options. Recycling used oil, antifreeze, metal and batteries and recovery and reuse of washing fluids are all examples of programs which could be implemented in maintenance operations' waste management programs.



Management of hazardous wastes appears to be the key issue with respect to current Transport Canada R&D programs. Hazardous wastes are generated through various fleet and infrastructure maintenance activities, including the phase-out of banned substances (PCBs and CFCs), disposal of waste solvents, paints, aerosols, pesticide and herbicide containers, etc. Identification of banned products under the new Canadian Environmental Protection Act has led to accelerated phase-out programs such as the decommissioning of PCB-filled electrical equipment at Transport Canada airports and the inventory of chlorofluorocarbons (CFCs) at all federal facilities by Environment Canada.

A large component of R&D in waste management addresses technologies to dispose of or treat hazardous and non-hazardous wastes. As a result, improved designs and processes for incineration, neutralization, biodegradation, fixation and chemical/physical processing are developing. The broad scale and volume of research and development into treatment and disposal methodologies also provides opportunities for modification to accommodate special needs including treatment of wastes from domestic and international air, marine and surface mode travel.

The major problems in waste management generally stem from non-compliance. Whether the non-compliance is born of ignorance with respect to existing legislature or is driven by economics, the bottom line is that non-compliance often leads to deterioration of the Canadian eco-system at large, and places public health and safety at risk. Stiffer penalties for non-compliance in recent years for companies and prosecution of their executive officers exemplify the priority that the nation has placed on waste management legislation. Transport Canada, as a government agency, must therefore remain current on the issue of compliance with environmental regulations and set the example for other transporters.

3.5.2 Current Programs

Present waste management R&D by Transport Canada is rather limited. The Marine Group is currently investigating the nature and generation of ship's garbage and intends to establish a waste management system which will be environmentally sound. Other issues suggested for study by Transport Canada but as of yet unaddressed include:

- o ship sewage treatment and disposal;
- o control of contamination of Canadian waters from ballast exchange water; and
- o disposal of deck, cargo hold, and tank washings.

A review of outside literature dealing with marine wastes suggested that disposal of derelict ships, removal of asbestos and disposal of waste materials following spill cleanups may also be subjects for future study.

Disposal of air-side solid wastes from international flights was identified as a critical issue by the Transportation Development Centre. Transmission of foreign disease in air-side wastes was the reason for the concern.



Although this issue was examined at Lester P. Pearson Airport, a disposal alternative to the current thermopress system was not available (Honsberger et al, 1988). Current disposal costs for the wastes are considered exorbitant by Transport Canada (T. Smith, pers. com., 1990) and hence the management of air-side wastes at all of the international airports should be investigated.

The Airports Group is studying runoff effluent quality at Halifax International Airport. This study will address requirements to treat low pH runoff prior to release to the local watershed. Another program at Halifax is testing sealants to prevent entry of acidic runoff into groundwater via pyritic slate outcroppings. In addressing the problem of low pH runoff, the Group should also review current methodologies employed by metal mining operations on treatment and disposal of acidic mine drainage.

Although current studies of airport waste management are few, it should be noted that the Group has currently concluded studies in the management of glycol waste effluents at major federal airports as well as the development of an inventory and phase-out plan for PCB wastes at all Transport Canada airports. Conversations with airport managers and regional Transport Canada staff revealed that the PCB phase-out is well underway.

Other waste management subjects suggested for R&D through interviews with the Airports Group include:

- o examining the implications of dumping fuel from airborne aircraft in distress;
- o disposal guidelines for decommissioned underground storage tanks; and
- o programs for separation of garbage and recycling of same.

Following a recent accident attributed to ice on the wings of a passenger aircraft, Transport Canada issued a safety directive requiring all aircraft landing at Canadian airports in winter to be de-iced prior to take-off. This directive will lead to a substantial increase in the quantities of glycol used for de-icing at airports compared to previous years. Examination of options to recover and reuse glycol should therefore be undertaken in the interests of preservation of the environment and mitigation of costs for increased consumption.

Surface transport modes have only one project with waste management implications. The Policy and Coordination Group is compiling an inventory of CFCs and its uses at Transport Canada facilities. This will be the first step of a phase-out program to comply with Canadian Environment Protection Act (CEPA) regulations.

No current waste management R&D projects were identified under aviation mode operations.

Future waste management R&D programs at Transport Canada should attempt to introduce 4R strategies to existing programs. Recycling of glycol at



airports is one example of such a program. Other programs to consider include feasibility studies of:

- o waste oil collection and recycling;
- o wash water and solvent reuse;
- o waste drum collection for reconditioning; and
- o offering initiatives to private industry to encourage R&D to reduce waste packaging.

Transport Canada should also examine the potential to replace hazardous products with non-hazardous products.

These programs have application to virtually all modes of transport and can draw upon outside research as a starting basis.

3.6 Transportation of Dangerous Goods (TDG)

3.6.1 Background

The administrative problems posed by hazardous waste management, and the emergency preparedness issues raised by spill management converge at the issue of transportation of dangerous goods and hazardous wastes. Recognition of these problems led to the passing of the federal Transportation of Dangerous Goods Act (TDGA) and regulations under the act. Most provinces have adopted the TDGA for their own internal transportation of dangerous goods control programs or have drafted similar legislation.

The TDGA's major focus is to promote public safety during the transportation of dangerous goods. In maintaining this focus, most R&D under the Transport of Dangerous Goods Directorate addresses aspects of safe handling and transport of dangerous goods. Environmental considerations are not treated directly and thus the environmental component becomes merely a side-effect of this R&D (efforts to reduce accidents and spills through use of safer dangerous goods packaging, thorough inspections and monitoring of conveyance vehicles, and proper training for shippers and handlers will also reduce the risk of release of hazardous products to the environment).

The Transportation of Dangerous Goods Directorate (TDGD) within the Surface Group of Transport Canada, which administers the Act, must fill two roles in achieving its continuing goal of safe-guarding the public during the transportation of dangerous products. First, as a working corporation, the TDGD must take the lead role in development and selection of safe means to transport dangerous goods and hazardous wastes. Current R&D which exemplifies TDGD efforts to identify safe dangerous goods conveyance includes:

- o modelling fire and heat effects on pressure containment vessels;
- o evaluating tank car steels;



- o determining the dynamic effects of unrestrained liquid motion on tanker stability and developing recommendations for controlling liquid movement within the context of safety regulations and standards; and
- o examining the effects of fire on the thermal characteristics of pressure containment and proximity of relief valves under test conditions.

The second role of the TDGD in promoting public safety during dangerous goods transport is that of a managerial/regulatory agency. In this capacity, TDGD develops regulations, specifications, and guidelines under the TDCA, enforces these regulations through inspections and compliance monitoring and oversees the general operation of dangerous goods transport across the nation through information services, risk assessment, modelling and train marshalling.

3.6.2 Current Programs

The most recent R&D efforts by TDGD to accomplish these tasks include:

- o examining implications of train speeds on safety during transport of dangerous goods;
- o determining the feasibility of implementing an electronic way-bill system for rail transport of dangerous goods;
- o developing a knowledge-based scheduler for deliveries of dangerous goods in tanker trucks to customers (project initiated by the Transportation Development Centre);
- o developing performance and acceptance criteria for fibre-reinforced plastic (RFP) tankers;
- o developing an expert software package for accurate and prompt determination of correct operating procedures under the TDCA regulations;
- o developing a field communications set for use by spill or incident response teams;
- o developing a system of identifying tank cars under pressure and loaded with dangerous goods;
- o determining the effects of human interaction in the field of transportation with emphasis on dangerous goods;
- o developing detailed cost data on a sampling of dangerous goods incidents (for generating costs for Dangerous Occurrence Reports as well as for providing industry with costs of risk data);
- o researching technology required to retest specifications of compressed gas pressure vessels using acoustic emissions type testing;



- o participating in the 2nd International Specialist Meeting on Major Hazards in the Transport and Storage of Pressure Liquefied Gases; and
- o establishing freight train marshalling practices.

3.6.3 Proposed Programs

Proposed R&D under consideration by the TDGD for future funding includes:

- o examining tanker car insulation integrity;
- o developing an on board "Hot Box" radio system for identification and localization of dangerous goods cars;
- o examining reliability and effectiveness of current "Hot Box" designs for detection of overheating, defective, and otherwise unsafe rail cars;
- o reviewing current specifications for design of safety valves and considering the feasibility of field testing such valves;
- o examining stress crack corrosion on ammonia valves;
- o investigating quick connecting and filling practices to eliminate leaks;
- o developing universal field testing methods for tank cars;
- o developing improved methods for field inspections;
- o investigating effectiveness of currently used dangerous goods incident response expert systems;
- o establishing guidelines for defining a leak or emission, and when a rail car should be considered unsafe;
- o assessing risk from proximity to major rail corridors; and
- o establishing criteria for temporary storage/holding.

The above list does not include all of the proposed R&D projects currently being considered for funding by the TDGD. As mentioned previously, R&D by the TDGD does not address environmental concerns directly. Projects listed in this report, however, may have indirect impacts on the environment either because target objectives for new designs are set by environmental standards, or because the ultimate goal of the R&D is to promote public safety by reducing the risk of release of harmful products to the environment.

When approached for suggestions for further R&D with environmental implications, personnel in the TDGD offered the following:



- o investigating the feasibility of employing sophisticated surveillance and detection techniques to all transport modes to improve inspections of dangerous goods shipments; and
- o examining the viability of a continuously updated dangerous goods tracking network system.

The introduction of the Canadian Environmental Protection Act has necessitated cooperation between the TDG Directorate and Environment Canada to amend the TDG regulations. Research may be required to determine if products identified in CEPA's list of priority chemicals and products will require special treatment under the TDG regulations.

3.7 Infrastructure Issues

3.7.1 Background

The main environmental issues presented by transportation infrastructure relate to planning, construction/decommissioning, and maintenance activities.

Planning and design of new transportation infrastructure must consider all of the environmental issues listed previously in this paper, and address each issue preferably in an environmental impact assessment (EIA). Decommissioning of infrastructure (abandoned airfields, rail lines, etc.) requires development of objectives which establish a final condition for the site that is acceptable for the final intended use. These objectives should include:

- o establishment of intended land use;
- o establishment of parameters for soil and water quality;
- o acceptable concentration limits for these parameters; and
- o cleanup and proper disposal of wastes.

Maintenance of infrastructure may involve many aspects such as air quality (road dust suppression), spills or leakage (sewage facility integrity), or waste management (replacement of worn or obsolete equipment).

R&D related to infrastructure construction/ decommissioning and maintenance covers an extremely broad spectrum of activity with participation from both public and private sector. Since transportation infrastructure is similar to other public and industrial infrastructure, there is vast potential to adopt R&D from sources outside transport and modify it for the required purpose. However, Transport Canada should examine the usefulness of utilizing Geographic Information Systems (G.I.S.) for data analysis and site selection.



3.7.1 Current Programs

Most Transport Canada R&D of the infrastructure issue applies to airport maintenance activities. Work is also being carried out in the maintenance of harbours and navigable channels. Recent changes in national rail service may necessitate R&D in areas of decommissioning of abandoned lines and maintenance of lines remaining in service. This will involve removal and disposal of preservative-treated railway ties, cleanup of contaminated ballast, and decommissioning and cleanup of abandoned railyards.

Road transport R&D is probably not warranted, as roads and highways are under provincial jurisdiction.

Recent federal policy changes to lease federally-owned transportation infrastructure (in particular, airports) to private interests will necessitate development of protocols to establish environmental liability. Without a clear "snapshot" or baseline of the site's environmental status prior to take over by the new tenant, Transport Canada could be held liable at the termination of the lease for cleanup of site contamination caused by the tenant's operations. Research and development of the criteria to establish the parameters for this baseline could proceed in cooperation with potential tenants and Environment Canada.

Other subjects for R&D consideration include:

- o Development of Environmental Impact Assessment (EIA) guidelines for siting infrastructure;
- o Development of decommissioning guidelines for abandoned infrastructure;
- o Development of expert systems for EIAs; and
- o Utilization of Geographic Information systems for site selection.



4. IMPLEMENTATION STRATEGY

Implementation of Environmental R&D goals should reflect the multi-jurisdictional interests inherent in the key environmental issues. Environmental problems have transboundary aspects, either through migration of pollutants or transit of vehicles. Another way of stating this is that the emissions can cross jurisdictional boundaries as can the emission sources (vehicles) can cross boundaries.

The prime implementation strategy for Transport Canada should be to seek opportunities to utilize multi-jurisdictional initiatives. This would take the form of identifying and seeking joint initiatives with:

- o the Canadian government
 - Environment Canada
 - Energy, Mines, and Resources
 - Department of National Defence;
- o Provincial Governments and Municipalities
 - Environment Ministries
 - Transport Ministries
 - Energy Ministries
 - Transit Authorities
 - Regional Governments;
- o U.S. Federal & State Governments
 - United States Department of Transportation
 - Environmental Protection Agency
 - State & Regional Environmental Agencies, NASA
 - Transit Authorities;
- o International Agencies and Associations
 - UN Agencies, OECD, etc.
 - Environment/Energy/Transport Agencies, IEA, ECMT
 - Modal Associations, e.g. ICAO, IMO; and
- o Vehicle/Component/Infrastructure Private Sector
 - Manufacturers, Designers
 - companies
 - associations, local/international
 - User groups/special interest groups.

It is suggested that transportation-related environmental R&D performed in Canada meet one or more of the following criteria:

- o it is unique to Canada or Canadians;
- o it complements other research conducted elsewhere;
- o international or other jurisdictional support is available for the work to be done in Canada; or



- o it has short- or long-term consequences based on qualitative risk assessment.

A similar set of the criteria could be developed for Transport Canada support of other jurisdictional initiatives elsewhere.

The role of Environmental Coordinator should be consolidated and developed to: develop risk assessments for the various issues; facilitate inter-modal and inter-jurisdictional coordination and communications; and to examine contracting-out policies that will be consistent with achieving sustainable development.

It should be recognized that various geographic locations may have special problems that would require specific areas of R&D (e.g., acid drainage at Halifax airport).



5. RESOURCES

From our brief contacts with senior staff in the various modal groups at Transport Canada, we would consider that Transport Canada is well staffed managerially and competent to respond to most environmental research and development in the following areas:

- o Surface: strong capabilities in engine emissions and less capability in spill management.
- o Marine: strong capabilities in spill management.
- o Airports: strong capabilities in noise R&D, with a lesser capability in terms of surface issues such as spill management and waste management.
- o Aviation: strong capabilities in all areas.

In addition to the R&D capabilities listed above, Transport Canada also has a Memorandum of Understanding (MOU), with the National Research Council (NRC). Under this agreement, the NRC carries out basic research under the direction of Transport Canada.

For direction of research and development needs, the newly created Environmental Coordinator role in the Policy and Coordination Group should be looked at as an opportunity to fill gaps in environmental management capabilities in all modes. This position should play a key role in facilitating the sharing of information and intermodal "cross-fertilization".

Our perception of technical support for "environmental managers" within Transport Canada is that it is relatively non-existent. The current "freeze" on staffing within Transport Canada makes continuing selective, case-by-case, use of outside environmental specialists necessary to support the R&D efforts of Transport Canada. The level of specialist support required for these relatively short-term projects would encompass a range of hands-on scientific and engineering expertise to policy research planning and project management. Thus, most of the new R&D projects may need to be contracted out.



6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

An inventory of the current Transport Canada R&D programs indicates high levels of effort are currently being expended in studies of engine emissions, marine spills and transportation of dangerous goods. Allocation of resources to these endeavours appears to be well-founded although consensus among Transport Canada staff is that the resources are not adequate. These issues owe much of their current high profile to transport activities and hence it is logical that transportation assign high priorities for R&D to these areas. The remaining issues are the subjects of numerous R&D programs by various agencies in both the public and private sectors. Research priorities should therefore be lower in these areas since results from outside studies may be adapted to suit Transport Canada's needs.

6.2 Engine Emissions

Transport Canada's engine emission R&D seems focussed towards studies of aircraft and motor vehicle emissions with very little funding allocated to studies dealing with marine and rail transport engine emissions. This can be explained by the fact that much of the motor vehicle R&D will have direct application to both marine and rail modes. Transport Canada researchers also point out that marine emissions are not significant in context of the entire transportation contribution to air pollution. Therefore, it appears that Transport Canada's R&D efforts concerning engine emission issues are adequate.

6.3 Long-term Climatic Changes

Short- and long-term climatic change issues dictate that Transport Canada's priorities should be to:

- o develop alternatives for CFCs from all modes;
- o evaluate options to decrease dependence on fossil fuels; and
- o investigate and respond to adverse upper atmospheric processes which may result from high altitude and/or supersonic transport.

Clearly, none of these initiatives will occur overnight. R&D is necessary and current efforts are not adequate. Because these issues are global, high priority should be given to seek out international R&D initiatives to support, or alternatively, to obtain international support for Transport Canada initiatives.



6.4 Noise

Current Transport Canada initiatives with respect to noise control should continue. The level of effort appears to be appropriate along with the intermodal balance. Research areas requiring particular continued emphasis are:

- o technological
 - engine, mechanical design
 - noise control
 - materials science;
- o predictive
 - improved measurement vs. modelling correlation (model development);
- o sociological
 - physiology/psychology of noise response; and
- o managerial
 - land use management
 - infrastructure planning.

6.5 Spills and Leaks

Spill prevention R&D should be given the highest priority due to the present inadequacies identified in national spill response capabilities. Spill management R&D programs currently emphasize marine transport. Although spills from ocean-going vessels are often large and may attract considerable media attention, the probability of land-based incidents is far greater due to the density of road traffic as compared to marine traffic. Since land-based spills can pose immediate hazards to human health and safety through contamination of ground and surface water as well as contamination of public and private property, R&D for management and prevention of land-based spills merit priority. Leak minimization and remediation technology from underground storage tanks (USTs) should also be considered a priority R&D topic because of the dangers of groundwater contamination and the risk of explosive vapours.

6.6 Waste Management

Very few waste management studies are underway in Transport Canada's R&D program. Past trends for fund allocation in this R&D area appear to be driven by federal environmental legislation (Chlorobiphenyl and Chlorofluorocarbon regulations previously under the Environmental Contaminants Act). This program of evaluating inventories of hazardous wastes and developing national waste management plans will likely continue, and should continue with the recent introduction of the Canadian Environmental Protection Act (CEPA). Transport Canada should also consider means to adapt 4R waste management strategies to current operating systems as well as replacement of hazardous products with non-hazardous products



where possible (perhaps by the use of environmentally sound contracting out strategies).

6.7 Transportation of Dangerous Goods

Transportation of dangerous goods (TDG) studies by Transport Canada place emphasis on rail service activities. This may be due in part to the federal government's ties with the national railway companies, and the fact that TDG R&D from rail studies may be adapted to other transport modes. Since the TDG Directorate is a regulatory body as well as a "working corporation" devoted to the safe transport of hazardous products, this group follows two separate routes in its R&D program. As a working corporation, the TDGD should take a lead role in the research and development of safe containers and vehicles as well as monitoring equipment to ensure the integrity of dangerous goods containers during transport. In its regulatory capacity, the TDGD should pursue R&D which assists in the day-to-day management of dangerous goods handling and transport, including improved inspection techniques and prompt, accurate application of the TDG act and regulations. As a regulator, the TDG should also seek cooperation from other federal departments (in particular, Environment Canada) for assistance in initiating and performing R&D. Although the current level of effort regarding this issue is probably adequate, the relatively high number of offenses committed under TDG Regulations and comments from industry may indicate further requirements for standardized training and possibly simplification of the system.

Although the manifest system facilitates "cradle to grave" tracking of dangerous goods, an easily accessible system for tracking dangerous goods shipment is not yet available. If feasible, such a system would be an invaluable aid to contingency planners.

6.8 Infrastructure Issues

Due to the fact that transportation infrastructure is similar to other forms of municipal and industrial infrastructure, and that other environmental issues play a large role in infrastructure development/ decommissioning and maintenance, there is a broad base of R&D in this area to draw from. Therefore R&D priorities in this area should probably be lower for this issue. Programs for infrastructural R&D generally have been, and should continue to be adaptations of other R&D programs.

Issues to consider for future infrastructural R&D should include:

- o guidelines for decommissioning abandoned infrastructure;
- o guidelines for environmental impact assessments;
- o establishment of parameters to define environmental baseline conditions at federal facilities leased to private interests; and



- o utilization of Geographic Information systems for data analysis and site selection.

A recurring theme in literature and interviews with Transport Canada personnel involved in R&D programs is the desirability for expert system software for use with:

- o spill management;
- o hazardous waste management;
- o compliance with the Transportation of Dangerous Goods Regulations; and
- o environmental impact assessment development.

Given the advances in personal computer technology, the complexities and importance of these issues, and the broad base of knowledge required to competently fulfill the requirements of these issues, development of these expert systems merits a high priority.



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APPENDIX A
TRANSPORT CANADA
INVENTORY OF CURRENT ENVIRONMENTAL R&D



TRANSPORT CANADA
INVENTORY OF CURRENT ENVIRONMENTAL R&D

ACTIVITY PROJECT	STATUS	ISSUES ADDRESSED	RATIONALE	ACTUAL OR POTENTIAL RESEARCH SPONSORS
SELECTION				
Impacts of NO_2 Emissions above 900 m.	Proposed	Exhausts, Greenhouse Effect, Stratospheric Ozone	Little is known about the impacts of NO_2 above 900 m. New NO_2 emission standards are, however, about to be implemented.	ICAO, FAA and NASA Interest Areas. Opportunities for Joint Funding & Collaboration
Hydrogen as an Alternative Fuel for Supersonic Aircraft.	Proposed	Exhausts, Greenhouse Effect, Stratospheric Ozone	Combustion of hydrogen fuel has the potential of yielding minimal impact on the stratospheric (vs. organic fuel combustion products).	ICAO, FAA and NASA Interest Areas. Opportunities for Joint Funding & Collaboration
Critical Evaluation of the NO_2 Emissions Research carried out by Engine Manufacturers.	Proposed	Exhausts, Greenhouse Effect, Stratospheric Ozone	Figures generated by manufacturers are used to assess compliance with standards. Because of the potential conflict of interest, independent review is necessary.	
Emission Sampling Problems for the Program vs. the Turbines.	Proposed	Exhausts, Greenhouse Effect, Stratospheric Ozone	Compliance with standards cannot be assessed until representative sampling methods are developed.	ICAO, FAA and NASA Interest Areas. Opportunities for Joint Funding & Collaboration
Alternatives to Rules for Demand Fire Control.	Proposed	Stratospheric Ozone	Discharge of CFC's directly to the stratosphere (as in onboard fire control) is potentially more significant in terms of ozone destruction than equivalent ground level releases.	ICAO, FAA and NASA Interest Areas. Opportunities for Joint Funding & Collaboration
Aerodynamics and Combustion Efficiency.	Active	Exhausts, Greenhouse Effect, Stratospheric Ozone	Improved efficiency yields reduced emissions.	MSC-199 Activities
Rotary Airfoil Efficiency.	Active	Exhausts, Greenhouse Effect, Stratospheric Ozone	Improved efficiency yields reduced emissions.	MSC-199 Activities



TRANSPORT CANADA
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ACTIVITY PROJECT	STATUS	ISSUES ADDRESSED	RATIONALE	ACTUAL OR POTENTIAL RESEARCH SPONSORS
Operational Efficiency.	Active	Emissions, Noise	Optimization of aircraft take-off profile to maximize efficiency, minimize emissions and noise.	TC
Methods of Aircraft Drag Reduction.	Active	Emissions, Greenhouse Effect, Stratospheric Ozone	Improved efficiency yields reduced emissions.	MRC-TPP Activities
Atmospheric Research & Sampling Aircraft.	Active	Emissions, Greenhouse Effect, Stratospheric Ozone	Better understanding of atmospheric processes requires improved monitoring capabilities.	MRC-TPP
Gas Turbine Engine Technology	Active	Emissions, Greenhouse Effect, Stratospheric Ozone	Improved efficiency yields reduced emissions.	MRC-TPP
- Gas-Path Analysis Techniques - Computer Models & Techniques to Simulate Dynamic Performance - Experiments and Evaluations to Reduce Wear - Operations of Test Cells for Engine Evaluation.				
Development and Application of Diagnostic Techniques and Combustion Analysis Methods.	Active	Emissions, Greenhouse Effect, Stratospheric Ozone	To permit more efficient designs to be developed.	MRC-TPP
Development of Methods to Measure and Control Size Distribution of Atomized Droplets in High Velocity Streams.	Active	Emissions, Greenhouse Effect, Stratospheric Ozone	Improved efficiency yields reduced emissions.	MRC-TPP
Experiments in Combustion Characteristics of Specific Gaseous and Liquid Fuels in Continuous Combustion Regimes (e.g. Gas Turbines).	Active	Emissions, Greenhouse Effect, Stratospheric Ozone	Alternate fuels research can lead to better engine designs and better fuel designs.	MRC-TPP



TRANSPORT CANADA
INVENTORY OF CURRENT ENVIRONMENTAL R&D

ACTIVITY PROJECT	STATUS	ISSUES ADDRESSED	RATIONALE	ACTUAL OR POTENTIAL RESEARCH SPONSORS
<u>MARINE</u>				
Quiet, efficient and damage-resistant propellers.	Active	Emissions, Greenhouse Effect, Noise	Improved modelling/testing allows improved design which yields improved efficiency and quieter operation.	MRC-TPP Activity, of IMO Interest
Fuel Quality/Reliability vs. Emissions.	Proposed	Emissions, Greenhouse Effect	Cleaner (higher quality) fuel leads to lower emissions.	IMO Interest Manufacturer, Shipping Co Interest
Engine efficiency. (see SURFACE)	---	---	---	---
Experiments and tests in ship propulsion and resistance.	Active	Emissions, Greenhouse Effect, Noise	Improved modelling/testing allows improved design which yields improved efficiency and quieter operation.	MRC-TPP
Diversification of existing numerical models to hydroelastic modelling, wave pattern and resistance modelling, and modelling of screw propellers.	Active	Emissions, Greenhouse Effect, Noise	Improved modelling/testing yields improved efficiency and quieter operation.	MRC-TPP
Major spill response management.	Active	Spill prevention, planning, detection containment and cleanup/disposal (efforts to emphasize latter three issues).	Although some of this work may duplicate efforts under TSC/CCG, there may be rationale to develop spill management protocols and methods that may be integrated with the Emergencies Branch operations. Work by the other Transport Canada Groups in spill management should be examined to avoid unnecessary duplication of efforts.	CCG (Emergencies Branch) R&D and Engineering Studies Plan.



TRANSPORT CANADA
INVENTORY OF CURRENT ENVIRONMENTAL RSD

ACTIVITY PROJECT	STATUS	ISSUES ADDRESSED	NATIONALE	ACTUAL OR POTENTIAL RESEARCH SPONSORS
National Spill Response System.	Active	Main components of system to include national contact system, marine chart database, oil spill trajectory model, hazard information, recovery equipment locations, emergency personnel listings, and deployment logistics.	TSC/CCS Marine Program. Such a system is required because spill incidents usually cannot be forecast. This system efforts a state of immediate readiness to spill management personnel because all resources can be located and dispatched on short notice.	TSC/CCS Marine Program
Ship Safety.	Active	Ship safety.	Required to identify hazardous practices that may result in spillage.	CCS (Ship Safety Branch), RSD and Engineering Studies Plan
Rebids and Waterways Management.	Active	Breeding and ice management to control erosion/channel degradation.	CCS (MMA) RSD and Engineering Studies Plan. Project may have implications to prevention of spills, aquatic habitat quality, and control of erosion.	CCS (MMA), RSD and Engineering Studies Plan
Spill prediction/tracking.	Active	Oil drifting, spill tracking, thermal imaging (especially in the 12 to 16 micron thermal imaging spectrum). Also addresses training of Search and Rescue (SAR) staff in SARBAT and use of protective equipment and clothing.	This program may provide useful input to oil spill management in cases where spill containment is delayed or breached (ie due to inclement weather) or response is initiated some time after the spill incident. This may however, be a duplication of effort, since TSC/CCS Marine Program Phase II (Detection and tracking of submerged oil) may be studying the same problem.	CCS (SAR) RSD and Engineering Studies Plan.



TRANSPORT CANADA
INVENTORY OF CURRENT ENVIRONMENTAL R&D

ACTIVITY PROJECT	STATUS	ISSUES ADDRESSED	RATIONALE	ACTUAL OR POTENTIAL RESEARCH SPONSORS
Beach Cleaning.	Proposed	This phase of the program has not been completely addressed.	Potential opportunities to cooperate with Environment Canada (ie Wildlife or Fisheries branches). As coastal areas are extremely sensitive areas environmentally (due to presence of marine mammals, birds, etc.), the primary efforts in marine spill management should be directed at preventing the excursion of oil spills into beach areas. When this is not possible immediate efforts to minimize damage are required.	TSC/CCO Marine Program, Phase 1
Generation and treatment of ship garbage.	Active	Current status of ship waste problems based on inventories of ships, characteristics of wastes, waste management philosophies and current regulations and compliance. Also addresses desired position in terms of waste reduction and treatment, collection sites, regulatory compliance, and cost/benefit.	Required to generate waste management strategy.	TSC/CCO Marine Program
Arctic pollution prevention studies.	Active	Development of regulations to prevent Arctic pollution.	Arctic ecosystem is very sensitive to pollution, and clean up and remediation in Arctic climates are difficult.	CCO/NAO

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ACTIVITY PROJECT	STATUS	ISSUES ADDRESSED	RATIONALE	ACTUAL OR POTENTIAL RESEARCH SPONSORS
<u>AIRPORTS</u>				
Airport (Noise) Externalities.	Active	Noise	The highest profile environmental impact in the vicinity of airports is due to noise.	ICAO, FAA
Predictor (model) of Aircraft Engine Run-Up Noise Levels in the Vicinity of Airports.	Proposed	Noise	Run-up noise levels identified as a significant contributor to noise in the vicinity of airports.	AG and TDC
Fuels Handling, Venting/Dumping, and Spilling on Engine S/U or S/D.	Proposed	Emissions	The feasibility/development of changes to current practices requires study.	ICAO, FAA
Fire Training, Emergency Response Fire Drills, Combustion Emissions.	Proposed	Emissions	During such drills, significant emissions may occur. The magnitude and potential impact have not been addressed.	ICAO, FAA
Improved Noise Model vs. Perceived Noise Correlations.	Proposed	Noise	Improved modellings vs. monitoring correlations yields improved predictive capability which can yield improved response/prevention and improved new design of facilities.	ICAO, FAA
Emissions Monitoring/Modelling Correlation Studies.	Active	Emissions	Improved modelling vs. monitoring correlations yields improved predictive capability which can yield improved response/prevention and improved new design of facilities.	ICAO, FAA
Wetlands construction for treatment of Acid Drainage at Halifax International Airport.	Completed	Liquid waste management, treatment of effluent to achieve stormwater discharge requirements.	Current effluent from the airport has a pH too low for release as stormwater effluents.	AG



TRANSPORT CANADA
INVENTORY OF CURRENT ENVIRONMENTAL R&D

ACTIVITY PROJECT	STATUS	ISSUES ADDRESSED	RATIONALE	ACTUAL OR POTENTIAL RESEARCH SPONSORS
Consultative system for environmental assessment.	Completed	Infrastructure/Miscellaneous. Development of an expert system for environmental screening.	Requirement for system to assist environmental officers involved in assessments and to assure quality in these assessments and decisions was identified by AG.	AG
Develop and evaluate pyritic slate sealants.	Completed	Liquid waste management. Development of sealant to prevent infiltration of acidic airport runoff into groundwater.	Current runoff quality at Halifax International Airport not suitable for release.	AG
Investigation of subsurface contamination beneath airports.	Active	Spills/leakage. Migration of contaminants in soil and groundwater, sampling protocols for identification and analysis of contaminants.	Due to various fuels and chemicals released at airports, it is logical that contamination monitoring be established.	AG
Calcium magnesium acetate (CMA) feasibility study.	Completed	Liquid waste management. Cost benefit of using CMA vs. urea as a deicing agent, and environmental impacts of CMA at airports.	Perceived need to improve safety, capacity and efficiency of Canadian airports. Environmental impact assessment required to assure minimum damage to environment.	AG



TRANSPORT CANADA
INVENTORY OF CURRENT ENVIRONMENTAL R&D

ACTIVITY PROJECT	STATUS	ISSUES ADDRESSED	RATIONALE	ACTUAL OR POTENTIAL RESEARCH SPONSORS
<u>SURFACE</u>				
Reduction of Emissions from IC Engines - Surface, Air, Marine.	Active	All	Emission reductions required to improve air quality, abate long term climatic change.	USEPA, State & Provincial, OECD
Improved Emissions Inventories.	Proposed	Emissions, Noise	Improved emission inventories permit a better understanding of problems and the results of emission changes, and allow better policies to be developed.	USEPA, State & Provincial, OECD
Improved Health (Toxicology) Studies.	Proposed	Emissions, Noise	Better knowledge of health effects of pollutants allow effort to be placed where it will do the most good (i.e. facilities prioritizing of pollutants).	USEPA, State & Provincial, OECD
The Use of BATEA Objectives to be Investigated for all presently regulated vehicles and to be extended to alternative fuel vehicles.	Proposed	Emissions	Pre-regulatory feasibility study required. Defines areas of practicality/impracticality.	USEPA, State & Provincial, OECD
Assessing the feasibility for achieving on-road levels of emission control for industrial engines.	Proposed	Emissions	Pre-regulatory feasibility study required. Defines areas of practicality/impracticality.	USEPA, State & Provincial, OECD
The feasibility of adopting emission reduction targets for locomotive (railway) and marine vessels, including addressing the feasibility of adopting emission controls for aircraft engines.	Proposed	Emissions	Pre-regulatory feasibility study required. Defines areas of practicality/impracticality.	USEPA, IMO, OECD, ICAO
Characterization and impact assessment of gasoline volatility.	Proposed	Emissions	A significant contributor to VOC emissions (yielding near-ground ozone increases). A simple reduction in this property could yield reduced emissions.	Federal, provincial, state, OECD agencies



TRANSPORT CANADA
INVENTORY OF CURRENT ENVIRONMENTAL R&D

ACTIVITY PROJECT	STATUS	ISSUES ADDRESSED	RATIONALE	ACTUAL OR POTENTIAL RESEARCH SPONSORS
Impacts of controlling the aromatic content of gasoline.	Proposed	Emissions	A significant contributor to VOC emissions (yielding near-ground ozone increases). A simple reduction in this property could yield reduced emissions.	Federal, provincial, state, OECD agencies
The use of MMT and other additives to motor fuels that may have a direct or indirect effect on health or the environment will be studied.	Proposed	Emissions	Better knowledge of health effects of pollutants allow effort to be placed where it will do the most good (i.e., facilitates prioritizing of pollutants).	Federal, provincial, state, OECD agencies
The benefits of reduced sulphur content in diesel fuel to be evaluated for all existing uses.	Proposed	Emissions	Pre-regulatory evaluation.	Federal, provincial, state, OECD agencies
Investigate the need to at least maintain or possibly improve cetane levels for future diesel engines.	Proposed	Emissions	Pre-regulatory evaluation.	Federal, provincial, state, OECD agencies
Investigate the need to specify a T90 temperature for diesel fuels.	Proposed	Emissions	Pre-regulatory evaluation.	Federal, provincial, state, OECD agencies
Examine the need to reduce the aromatic content of diesel fuels.	Proposed	Emissions	Pre-regulatory evaluation. A significant contributor to VOC emissions (yielding near-ground ozone increases). A simple reduction in this property could yield reduced emissions.	Federal, provincial, state, OECD agencies
Investigate "Stage I" and "Stage II" vapour recovery controls and assess the effect of exemptions for low volume facilities, of regional vs. national control, and of implementation schedules cost and effectiveness.	Proposed	Emissions	Pre-regulatory evaluation. A significant contributor to VOC emissions (yielding near-ground ozone increases). A simple reduction in this property could yield reduced emissions.	Federal, provincial, state, OECD agencies



TRANSPORT CANADA
INVENTORY OF CURRENT ENVIRONMENTAL RD

ACTIVITY PROJECT	STATUS	ISSUES ADDRESSED	RATIONALE	ACTUAL OR POTENTIAL RESEARCH SPONSORS
Investigate the use of automatic shut-off valves for refuelling of propane tanks.	Proposed	Emissions	Increased use of propane may lead to requirement for more safety devices. Low priority item.	Federal, provincial, state, OECD agencies
Diesel engine Health Monitoring.	Active	Emissions, Greenhouse Effect	Better knowledge of health effects of pollutants allow effort to be placed where it will do the most good (i.e. facilitates prioritizing of pollutants).	MRC-Tpp
Alternative Fuels to Reduce Pollution.	Active	Emissions, Greenhouse Effect	Lower or non carbon or biomass fuels can reduce emissions including CO ₂ .	MRC-Tpp
Regenerative Powertrains to Reduce Fuel Consumption. (Development and demonstration for urban vehicles)	Active	Emissions, Greenhouse Effect	Energy losses due to braking in urban areas can be significant. Methods of recovering that energy can result in improved energy efficiency.	MRC-Tpp
Advanced Materials to Improve Performance and Life of Power Systems.	Active	Emissions, Greenhouse Effect, Noise	Improvements in performance and lifelines lead to improved efficiency over a longer period.	MRC-Tpp
Deeper Understanding of Wheel-Rail Interactions to Reduce Wear and Rolling Resistance.	Active	Emissions, Greenhouse Effect, Noise	Reduced wear and rolling resistance translate to reduced energy losses in motion.	MRC-Tpp
Innovative Technologies to Increase Train Cost-Effectiveness.	Active	Emissions, Greenhouse Effect, Noise	Increased cost effectiveness can lead to higher levels of utilization which results in better energy consumption per unit load ratios.	MRC-Tpp
Advanced Train Control Systems for Increased Efficiency and Safety.	Active	Emissions, Greenhouse Effect, Noise	Advanced control systems improve energy efficiency through reduction in start/stop frequency maintaining consistent speeds, and potentially better load management.	MRC-Tpp



TRANSPORT CANADA
INVENTORY OF CURRENT ENVIRONMENTAL R&D

ACTIVITY PROJECT	STATUS	ISSUES ADDRESSED	RATIONALE	ACTUAL OR POTENTIAL RESEARCH SPONSORS
Real-time precision Vehicle Locators.	Active	Emissions, Greenhouse Effect, Noise	Advanced control systems improve energy efficiency through reduction in start/stop frequency maintaining consistent speeds, and potentially better load management.	MRC-Tpp
Special Considerations for Land Transport in Northern Canada. (i.e. Low Temperature Performance)	Active	Emissions, Greenhouse Effect, Noise	Different operating conditions affect performance and efficiency necessitate special considerations. These need to be identified and quantified.	MRC-Tpp
Drag Reduction of Surface Vehicles (Automobiles, Buses, Trains).	Active	Emissions, Greenhouse Effect, Noise	Drag yields energy losses. Reduction in drag yields improved energy efficiency.	MRC-Tpp
Development of Improved Wind Tunnel Test Methods.	Active	Emissions, Greenhouse Effect, Noise	Better wind tunnel applicability yields better designs for improved aerodynamics. Improved aerodynamics improves efficiency.	MRC-Tpp
Wind Tunnel Investigations of Railway Cars.	Active	Emissions, Greenhouse Effect, Noise	Better wind tunnel applicability yields better designs for improved aerodynamics. Improved aerodynamics improves efficiency.	MRC-Tpp
Correlate diesel performance with residual and lower grade's of fuel.	Active	Emissions, Greenhouse Effect, Noise	The effect of fuel grade on energy efficiency requires study.	MRC-Tpp
Development and Application of methods of exhaust gas analysis (particularly diesel particulates) and correlation of emissions to fuel properties and combustion processes.	Active	Emissions, Greenhouse Effect, Noise	It is necessary to be able to accurately monitor, analyze, and model emissions to assess the performance of any new design.	MRC-Tpp
Development of analytical techniques for quantifying diesel spray characteristics and combustion.	Active	Emissions, Greenhouse Effect, Noise	Better quantification yields better performance testing and ultimately results in designs.	MRC-Tpp

TRANSPORT CANADA
INVENTORY OF CURRENT ENVIRONMENTAL RED

ACTIVITY PROJECT	STATUS	ISSUES ADDRESSED	RATIONALE	ACTUAL OR POTENTIAL RESEARCH SPONSORS
Engine Idling Procedures, Needs, and Alternatives.	Proposed	Emissions, Greenhouse	The traditional "diesel idling" assumptions require challenge and study. This can be a significant source of urban (local) particulate, toxics, etc.	MRC-TTP
Noise and Vibration.	Proposed	Noise	Basic RED. Necessary understanding.	MTA
Methanol in Diesel with Glow Plug to Minimize Gaseous & Particulate Emissions.	Active	Emissions, Greenhouse Effect Engine emissions/fuel. Detailed documentation of aldehydes, unburned methanol and NO _x in exhaust stream, optimum placement and surface temperature of glow plug.	Determine viability of methanol as a motor fuel, determine modifications required to engines for optimum performance with minimum emissions.	TDC
Train speed study.	Active	TGG. Speed of trains and the implications to safe transport of dangerous goods. Also assesses modal shifts from rail to motor carrier.	Results of the study may form guidelines for expedient yet safe transport of dangerous goods by rail.	TGG
Modelling fire effects on tanks.	Active	TGG. Effects of fire and high temperature on pressure containment vessels for transportation of dangerous goods. (Scale model study).	The study may provide data to assist fire-fighting crews accommodate pressure containment vessels exposed to high temperatures or flame. Risk data from the study may also define safe distances of separation between the affected vessels and infrastructure or public or private facilities.	TGG



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INVENTORY OF CURRENT ENVIRONMENTAL R&D

ACTIVITY PROJECT	STATUS	ISSUES ADDRESSED	RATIONALE	ACTUAL OR POTENTIAL RESEARCH SPONSORS
Evaluation of tank car steels.	Active	T04. Design characteristics of new steels in containment vessels for dangerous goods.	Useful specifications for rail tanker steels may be derived from this study. This will allow efficient use of materials and lessen the risk of vessel failures through inadequate materials.	T04D
Electronic waybill for rail transport of dangerous goods.	Active	T06. Feasibility of using an electronic waybill consistent with T04 legislation.	Computerized waybills would reduce paper work and facilitate locating dangerous goods in transit. Implications to environment include quick identification of dangerous goods in trouble areas, and the potential to link an expert system to the waybill database, allowing immediate access to spill/disaster information.	T06D
Knowledge based dispatcher.	Active	T09. Development of a vehicle dispatcher's assistant to provide expert decision aid in scheduling deliveries of dangerous goods in tanker trucks.	System would be employed to ensure that deliveries are handled safely with minimum impact to public health and safety and the environment.	T09D
RSP tank -- testing methodology.	Active	T06. Performance and acceptance criteria for Fiber-Reinforced Plastic (FRP) Tankers.	Standard criteria for FRP tankers would offer added protection from the dangers of leakage or rupture when loaded.	T06D
Safety ID of pressure tank cars.	Active	T05. Identification by electronic means of tank cars under pressure and loaded with dangerous goods.	Such a system facilitate identification of pressurized tankers which would save time in a crisis situation.	T05D



TRANSPORT CANADA
INVENTORY OF CURRENT ENVIRONMENTAL R&D

ACTIVITY PROJECT	STATUS	ISSUES ADDRESSED	RATIONALE	ACTUAL OR POTENTIAL RESEARCH SPONSORS
Expert system for 104.	Active	104. Development of a user-friendly computer program to facilitate correct interpretation and application of 104 regulations for shippers and handlers of dangerous goods.	Although development and use of the expert system does not offer direct aid to environmental protection, it will help to ensure that correct identification and documentation is established for dangerous goods in transit, which will be of value to emergency personnel in the event of an environmental accident.	1042
Acoustic Safesense Testing.	Active	104. Testing of specification compressed gas pressure vessels using acoustic emission technology.	Availability of such technology would aid in the prevention of leaks of compressed gases during transport.	1042
Tank thermal analysis.	Active	104. Study of thermal effects on pressure containment and proximity of relief valve.	In conjunction with the scale model tests of the effects of heat and flame on pressurized vessels, this study will provide data to assist fire fighting crews and establish safe distances of separation for each vessel from public and private facilities.	1042
Intermediate Bulk Containment (IBC) Testing.	Active	104. Verify character of IBC under operational conditions.	The study will develop guidelines for the safe operation of IBC and reduce the risk of spills.	1042
Liquid tanker stability.	Active	104. Effects of liquids sloshing in tanks and development of techniques to control this movement.	Results of the study will be used to establish safe operating and design parameters for tanks for transport of liquids thereby reducing the risk of ruptures and spills.	1042



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ACTIVITY PROJECT	STATUS	ISSUES ADDRESSED	NOTES/REMARKS	ACTUAL OR POTENTIAL RESEARCH SPONSORS
Review of hazards of dangerous goods in environment.	Proposed	TSB. Review lists of dangerous goods and identify potential detrimental effects on the environment. Modifications to transportation regulations may be made where handling of dangerous goods may cause undesirable environmental damage.	Priorities of TSB address public health and safety first, and environmental implications second. Regulations under CEPA to safeguard environmental concerns from damage due to handling of dangerous goods should be considered.	TSB/Environment Canada
Development of a field communications set for emergencies use.	Active	Safety (some relevance to Spills and Leaks).	Improve field communication and reduce confusion during emergencies.	TSB
Effects of human interaction on transportation of dangerous goods.	Active	Safety (some relevance to Spills and Leaks).	Determine the role of human interaction in dangerous goods situations.	TSB
Development of cost data for dangerous goods incidents.	Active	Risk Management, Spills and Leaks.	Establish perspective on situations which incur high costs and to produce risk data.	TSB
2nd International Specialist Meeting on Major Hazards in the Transport and Storage of Pressure Liquefied Gases.	Active	Risk management, ADP handling, Spills and Leaks, Evacuations.	To gain benefit of international experience and ADP in transport of dangerous goods.	TSB
Tanker car insulation integrity.	Proposed	Safety (relevance to Spills and Leaks).	Determination of characteristics of thermal insulation breakdown.	TSB
On board "Hot Spot" radio system for identification and location of dangerous goods cars.	Proposed	Safety (some relevance to Spills and Leaks).	To facilitate rapid identification and location of dangerous cars.	TSB
Reliability and effectiveness of current "Hot Spot" designs.	Proposed	Safety (relevance to Spills and Leaks).	Determination of reliability and effectiveness of currently employed systems for detection of trouble.	TSB

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ACTIVITY PROJECT	STATUS	ISSUES ADDRESSED	RATIONALE	ACTUAL OR POTENTIAL RESEARCH SPONSORS
Review of current specifications for design of safety valves.	Proposed	Safety (relevance to Spills and Leaks and Detonations).	Development of standards for safety valves.	TDGD
Stress crack corrosion on ammonia valves.	Proposed	Safety (relevance to Spills and Leaks and Detonations).	Determination of dangerous conditions for ammonia transport.	TDGD
Quick connecting and filling practices to eliminate leaks.	Proposed	Safety, Spills and Leaks.	R&D to facilitate quick coupling of filler apparatus to tanks with minimal product excursion.	TDGD
Universal field testing methods for tank cars.	Proposed	Safety (relevance to Spills and Leaks).	Avoid need for several test methods to accommodate different rail cars; prevent incorrect field test results. Avoid inaccurate field test results.	TDGD
Improved methods for field inspections.	Proposed	Safety (relevance to Spills and Leaks).	Prevent damage to containers during transport and subsequent release of hazardous products.	TDGD
Effectiveness of currently used dangerous goods containment restraint systems.	Proposed	Safety (relevance to Spills and Leaks).	Expedite and coordinate a safe thorough response to incidents involving dangerous goods.	TDGD
Feasibility of implementing the HEMS emergency response expert system.	Proposed	Safety, Spills and Leaks.		TDGD
Guidelines for defining leaks and emissions.	Proposed	Safety, Spills and Leaks.	Definitions required to differentiate unsafe from safe containers and rail cars.	TDGD
Risk from proximity to major rail corridors.	Proposed	Safety, Risk Assessment, Spills and Leaks	Assess risk to public in close proximity to rail corridor from potential dangerous goods incidents.	TDGD
Criteria for temporary storage/holding. (31)	Proposed	Safety, Spills and Leaks	Necessary for establishment of regulations or guidelines for temporary storage/holding.	TDGD



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ACTIVITY PROJECT	STATUS	ISSUES ADDRESSED	RATIONALE	ACTUAL OR POTENTIAL RESEARCH SPONSORS
Control of motor vehicle emissions.	Proposed	Engine emissions/fuel. Implications of the Motor Vehicle Safety Act to other modes such as rail, air, and marine. May involve changes to legislation regarding off-road vehicles.	Motor vehicle emissions are known to be a significant contributor to air pollution. Effects of emissions are not as well-documented and therefore should be evaluated.	ASP
Nitrogen Oxide (NO _x) Protocol.	Proposed	Engine emissions/fuel. Efforts to meet commitments on possible international protocols regarding nitrogen oxides.	Canada must keep pace with internationally-established protocols that affect global air quality.	ASP
Use (Inventory) of CFCs and halons 1211 and 1302.	Completed 1989	Engine emissions/fuel. Inventory of halon and CFC use in Transport Canada to be submitted to Environment Canada.	CFCs have been banned in Canada under CEPA because of their proven destructive effect on the ozone layer.	Policy and Coordination Group.
Applications/development of passenger car fleet fuel consumption model.	Active	Engine emissions/fuel. Passenger car fleet fuel consumption.	Valid model may be useful tool for forecasting emissions from passenger cars.	Road Safety and Motor Vehicle Regulation Directorate (RSMVRD).
Emissions from conventional and alternative automotive fuels.	Proposed	Engine emissions/fuel. Critical review, analysis, and correlation of existing data on emissions per unit of energy generated.	Provides a basis for comparison of automotive fuels on the basis of environmental parameters.	RSMVRD



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ACTIVITY PROJECT	STATUS	ISSUES ADDRESSED	RATIONALE	ACTUAL OR POTENTIAL RESEARCH SPONSORS
Development and application of the exhaust charged cycle (ECC) to conventional internal combustion engines.	Active	Engine emissions/fuel. Conservation of fuel.	Reduced fuel consumption will lead to reduced emissions.	EDMUND
Methanol-powered vehicle performance and emissions.	Awaiting Report	Engine emissions/fuel. Performance and emissions compared to conventional automotive fuels.	Rate environmental benefits/detracts of methanol fuels vs. conventional fuels.	EDMUND
Cold starting, emissions and energy efficiency of a flexible-fueled vehicle.	Active	Engine emissions/fuel. Air emissions.	Since fuels have distinct stoichiometric ratios, performance and emissions from the same engine burning an alternate fuel are expected to change.	EDMUND
Application of exhaust charge cycle (ECC) to reduce fuel consumption and emissions from methanol-fueled engines during cold starting.	Active	Engine emissions/fuel. Air emissions.	The worst emissions environmentally from IC engines will occur during incomplete combustion (ie when the engine is cold). Reduction of fuel during start-up may significantly reduce emissions from "cold" engines.	EDMUND
Comparative energy conversion efficiency of a methanol-fueled passenger car.	Project definition	Engine emissions/fuel. Relative efficiency of methanol vs. conventional motor fuels, air emissions.	Determine the viability of methanol as a motor fuel.	EDMUND



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ACTIVITY PROJECT	STATUS	ISSUES ADDRESSED	RATIONALE	ACTUAL OR POTENTIAL RESEARCH SPONSORS
Evaporative emissions from mechanical-fueled vehicles.	Proposed	Engine emissions/fuel. Air emissions.	Provide basis for comparison between conventional fuels and methanol. Evaporative emissions from gasoline are already well-documented and suggest that some volatile components of gasoline are harmful to public health and the environment.	ES&MD
Engine liner coatings - Phase I.	Active	Engine emissions/fuel. Installation of cylinder liner coatings in locomotive engines and evaluation of physical and wear properties.	Liner coatings may reduce friction losses in locomotive engines which would liberate more useful power at the same emission rate.	TBC
Highway snow drift control.	Completed	Infrastructure/maintenance. Reduction in maintenance costs associated with snow removal on roadways.	Reduction in snow removal and deicing requirements on pavement will decrease requirements for road-salting and sanding, which will improve the quality of runoff in roadside drainage.	TBC
Infectious materials packaging.	Active	Tbl. Establishment of lab tests and testing levels that reproduce the Canadian distribution environment for packaging for diagnostic specimens and cultures of infectious materials.	Definition of performance requirements for testing system which will facilitate handling and safe transport of infectious materials.	TBC (R&D cost sharing available).

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ACTIVITY PROJECT	STATUS	ISSUES ADDRESSED	RATIONALE	ACTUAL OR POTENTIAL RESEARCH SPONSORS
Reprenox to reduce emission.	Active	Engine emissions/fuel. Reduction of NO _x emissions for diesel engines operating on diesel or natural gas.	Comparison of Reprenox emission control system to ammonia injection into exhaust stream for NO _x control.	TDC
Expert systems development for spill response.	Proposed	Creation of a user friendly computer program to guide spill response managers through the cleanup operation.	Spill response requires immediate decision making that may become difficult, even for experienced managers, when under stress. An expert system would ensure that the response is well prepared and thorough.	CCG (Emergencies Branch/TDC)

